A Discriminant Analysis of Grain Market Structure in Selected States

By

Marcus E. Lower, E. Dean Baldwin
Donald W. Larson and Cameron S. Thraen

Selected Paper Prepared for Presentation at
The Annual Meeting of American Agricultural Economics Association (AAEA)
Utah State University
Logan, Utah
August 1-4, 1982

A Discriminant Analysis of Grain Market Structure in Selected States

By

Marcus E. Lower, E. Dean Baldwin
Donald W. Larson and Cameron S. Thraen

ABSTRACT

A grain marketing system paradigm is developed to identify the most important variables influencing grain market structure. Through discriminant analysis the basic hypothesis, that the grain merchandising industry contains distinct regions which are a function of production, marketing and transportation variables, is tested and accepted.

Biographical Data

Marcus E. Lower - B.S. and M.S. in agricultural economics at The Ohio State University.

E. Dean Baldwin - Associate Professor, Department of Agricultural Economics and Rural Sociology, The Ohio State University. Holds a research and Extension appointment in grain marketing.
B.S. - The Ohio State University
M.S. - University of Illinois
Ph.D. - University of Illinois

Donald W. Larson - Associate Professor, Department of Agricultural Economics and Rural Sociology, The Ohio State University. Holds a teaching and research appointment in grain marketing.
B.S. - South Dakota State University
M.S. - Michigan State University
Ph.D. - Michigan State University

Cameron S. Thraen - Assistant Professor, Department of Agricultural Economics and Rural Sociology, The Ohio State University. Holds a teaching and research appointment in marketing.
B.S. - Northern State College
M.S. - South Dakota State University
Ph.D. - University of Minnesota

A Discriminant Analysis of Grain Market Structure in Selected States

By

Marcus E. Lower, E. Dean Baldwin
Donald W. Larson and Cameron S. Thraen*

Introduction

Grain market structure can be defined as the organization of productive units in terms of the number and size of establishments. As a society we are interested in studying market structure because the structure influences market performance. Achieving satisfactory performance is an appropriate and frequently discussed goal for the grain sector of our economy. Prior research efforts have examined selected grain market structure and performance issues related to the 1960s and early 1970s. In these analyses, some of the authors have concluded that an inadequate data base limited their efforts and that much of the grain market structure and performance work has of necessity been general in nature (Jones, Caves and Clodius).

To pursue more analytical grain market structure and performance research, two regional research committees, the Southern Regional Grain Marketing Research Project S-115 entitled, "Alternative Structures for Increasing Efficiency in Inter and Intra Regional Grain Marketing Systems," and the North Central Regional Research Project NC-137 entitled, "Alternative Rural Freight Transportation, Storage and Distribution Systems," surveyed 3,400 firms from about 40 states in the U.S. for the year 1977. These data were summarized into state totals and were made available as a basis for a more detailed structural study of the grain merchandising sector in selected states in the U.S.

The purpose of this paper is to report the results of a discriminate analysis (DA) of the structural characteristics of grain merchandising facilities

---

*Research Associate, Associate Professors and Assistant Professor, respectively, Department of Agricultural Economics and Rural Sociology, The Ohio State University.

among three states (Illinois, Ohio and Alabama). This technique was used to classify specific facility types in each state and to identify those variables which were significant in the classification of sub-sets of facilities in these areas. The basic hypothesis tested was that the grain merchandising industry in each region contains a distinct set of facility types which are a function of selected production, marketing and transportation variables.

In the next section of this paper a conceptual paradigm is developed which helps identify the structure of the industry and the most important variables which may impact that structure. The following section presents the methodology and data used in the discriminant analysis and the results and conclusions are presented in the final section.

Grain Marketing System Paradigm

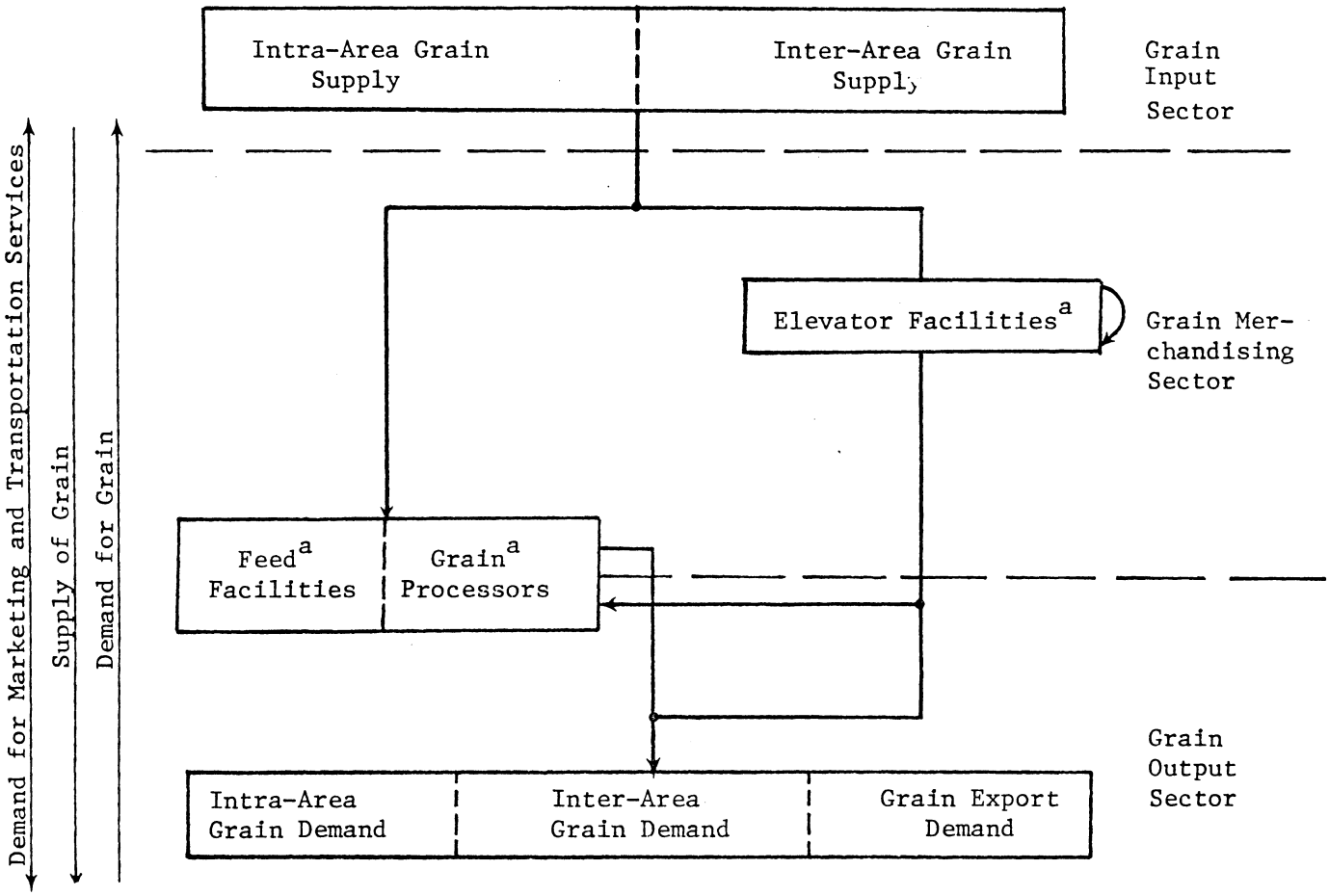
The structure of the grain marketing system can be delineated by the use of a conceptual paradigm within which the various supply and demand forces for grain and merchandising services interact (Figure 1). The paradigm contains three major structural sectors: (1) the grain merchandising industry, (2) the grain input sector, and (3) the grain output sector. In addition, the grain transportation sector is an integral part of all sectors.

The grain merchandising sector represents the structure of the grain merchandising firms in the grain marketing system. Included are such structural factors as the types, number and sizes of grain elevators, feed mills and manufacturers and grain processors.[1/] Grain elevators perform the exchange and physical marketing functions and allocate grain supplies through time and space to meet the demand of buyers. Grain processors including feed mills are included in this sector because these firms provide some of the exchange, spatial and temporal functions; however, these firms are also operating in the intra-area

---

[1/] In this study, facility types are the dependent variables.

Figure 1. Grain Marketing System Paradigm



The Transportation Sector is denoted by connecting lines and arrows.

[a]For definition of grain facility types, see Lower (1982).

demand subsector as buyers. Variables from the grain merchandising sector include facility types and storage, delayed pricing and drying functions.[2/]

The grain input sector represents the structure of the grain supply and service demand side of the grain marketing system. The inter-area supply subsector represents the volume of grain received from regions outside of the area

---

[2/]See Lower [1982] for a complete list of variables as specified within the paradigm.

and is used to satisfy the area's demand. Firms within this sector perform the exchange, spatial and temporal functions as a supplier of grain and are involved in the exchange function as buyers of marketing services from the merchandising industry. Input sector variables include farm size, number and types of farms, storage services and the percent of total grain receipts acquired from interstate sources.

The grain output sector depicts the grain and service demand side of the grain marketing system. The intra-area demand subsector includes the number and types of livestock producers, feed mills and manufacturers and grain processors within the area. The inter-area demand subsector represents the demand for grain from all non-export firms outside the area. The export demand sub-sector represents the demand for grain from exporters who are also located outside the area. The output sector variables include grain consuming animal units and the percent of total shipments to domestic points and to export locations.

The transportation sector cuts across each of the grain sectors acting as a cohesive agent tying together the grain sectors which perform the marketing functions. Variables in the transportation sector include the percent of the merchandising facilities total grain receipts and shipments that were transported by mode.

Data and Methodology

The primary data for this study were obtained from a 1977 North Central Southern Regional (NCSR) grain facility survey.[3/] Data from secondary sources including publications from the 1977 NCSR project, state Crop Reporting Services and the U.S. Department of Agriculture, were also used.

[3/] A grain facility or plant in this survey is one operating establishment or physical unit. In a firm which has more than one facility or plant, each plant is treated separately. For a definition of the facility types used in this study, see Larson, Lower, Baldwin and Sharp (1981).

All data from the NCSR surveys were aggregated into state data by the respective state representatives. An examination of the aggregated data indicated that it could not be used in its entirety for this research effort. Thus, individual firm data were acquired from the states of Alabama, Illinois and Ohio.

It was hypothesized that Illinois data would be representative of the market structure of the Western Corn Belt, that Ohio data would be representative of the Eastern Corn Belt, and that Alabama data would be representative of the grain deficit Southern United States. A chi-square test was used to examine for significant differences in mean levels of grain production and other variables and it was concluded that these states were statistically representative (Lower, 1982).

Discriminant Analysis

The discriminant analysis statistical technique permits the identification and analysis of differences among groups of observations resulting from variations in several characteristics simultaneously.[4/] Discriminate analysis involves two basic steps: (1) the evaluation of the characteristics for their ability to discriminate among the groups, and (2) the classification of observations into the group with characteristics most closely resembling their own.

The observations' characteristics, termed discriminant variables, are used to formulate linear combinations called discriminant functions. The general form of these functions is given as:

$$d_{km} = u_1 x_{1km} + u_2 X_{2km} + \ldots + u_i x_{ikm},$$

where d_{km} = the score of the discriminant function for observation m in group k;

x_{km} = the value of discriminating variable x_i for observation m in group k; and

---

[4/] For a more detailed explanation of discriminant analysis refer to Lower.

x_{km} = the standardized coefficient associate with variable x_i.

The derivation of the coefficients (u_i's) for the first discriminant function is such that the greatest separation of group means is achieved. For the second function group means separation is again maximized when the coefficients are derived with the added constraint that the values of the second cannot be correlated with those of the first function. This rule continues through the formulation of the remaining functions as the coefficient values of each may not be correlated with the preceding function while maximizing the separation of group means.

In this study, the discriminate functions identify the significant variables from the list developed from the paradigm to classify the grain facilities by type for each state or region. The significance of this classification or the power to discriminate is evaluated using five measures: (1) eigenvalue, (2) relative percentage, (3) canonical correlation, (4) Wilk's Lambda, and (5) chi-square. The larger the values assigned to all measures except for the Wilk's Lambda the more discriminate power exists in each function. For the Wilk's Lambda measurement, the smaller the value the more power possessed by the function

The selection of a heterogenous (homogenous) set of variables by the respective functions for each state or region is used to accept (reject) the general hypothesis of this study; that the grain structure in the U.S. is significantly different by region and that specified marketing and transportation variables could be used to classify these structures. Thus, if homogenous structures exist across regions, the set of significant variables in each function for each region will be identical and the hypothesis would be rejected.

Results

The discriminant functions for the Illinois data identified 19 variables which were significant at the one percent level (Table 1). The first two dis-

Table 1. Significant Structural Variables Selected by the Discriminate Functions to Classify Plants for Three Marketing Regions, Western Corn Belt, Eastern Corn Belt and Southern U.S. 1977

Variables	R E G I O N S		
	Western Corn Belt (Illinois)	Eastern Corn Belt (Ohio)	Southern U.S. (Alabama)
Total Grain Storage Capacity	X	X	X
Feed Processed	X	X	X
Processed Grain	X	X	X
Farm Storage Services	X	X	
Other Storage Services	X	X	
In House Storage Services	X	X	X
Delayed Pricing Services		X	X
Drying Services		X	X
Single Rail Car Grain Receipts	X	X	
Unit Train Grain Receipts	X		
Barge Grain Receipts		X	X
Truck Grain Shipments	X	X	
Single Car Grain Shipments	X	X	
Multi Car Grain Shipments	X	X	
Unit Train Grain Shipments	X	X	
Barge Grain Shipments	X	X	X
Percent of Total Receipts From Interstate Regions	X	X	X
Percent of Total Shipments to Interstate Regions	X	X	X
Percent of Domestic Non-export Shipments	X		X
Acres in Farms	X		
Bushels of Grain Produced	X		
Farm Numbers		X	
Grain Consuming Animal Units	X		

The "X" indicates that the variable is significant for the respective regions.

criminant functions defined by these variables achieved 97 percent of the explanatory power with the first function explaining 86.3 percent. The functions for the Illinois data possessed significant discriminatory power as demonstrated by the specific test measures cited (Lower, 1982).

Because the 19 different variables representing all four sectors of the grain and transportation paradigm were significant, the grain industry structure of the Western Corn Belt is classified by the structural and functional variables of all four sectors. The most significant variables were shipments of grain by mode of transportation, farm size, domestic shipments of grain as a percent of total shipments, and storing grain for others. The significance of the transportation sector variables and the grain storage variables reflect the importance of spatial and temporal movements of grain from the surplus grain producing Western Corn Belt to deficit grain producing areas, including export points. The significant farm size variable reflects the intensive economic interaction in the Western Corn Belt between specialized grain farms and elevators.

The 19 variables accurately classified most facilities by type for the Western Corn Belt region; only the country elevator and terminal elevator classifications were not significantly different (Table 2). The inability to differentiate between these two groups occurs because each specializes in the grain marketing function, receiving grain from farms and shipping grain to similar destinations.

The discriminant functions for the Ohio data identified 18 significant variables; however, the set of variables for the Eastern Corn Belt is different from the Western Corn Belt (Table 2). For example, delayed pricing, drying services and farm numbers were significant variables for the Eastern Corn Belt while farm size, grain production and percent of grain shipments to domestic demand centers as a percent of total shipments were significant for the Western

Table 2. Predicted Grain Facility Type Classifications in Percentages for Three Regions (Western Corn Belt, the Eastern Corn Belt and the Southern Corn U.S.

Facility Type	FACILITY TYPES Country Elevator	Terminal Elevator	River Elevator	Export Elevator	Feed Facility	Grain Processor
			Western Corn Belt (Illinois)			
Country Elevator	93.7	4.7	0.0	0.0	1.6	0.0
Terminal Elevator	69.0	31.0	0.0	0.0	0.0	0.0
River Elevator	1.5	0.0	98.5	0.0	0.0	0.0
Export Elevator	0.0	0.0	25.0	75.0	0.0	0.0
Feed Facility	16.7	0.0	0.0	0.0	83.3	0.0
Grain Processor	3.1	0.0	0.0	0.0	18.8	78.1
			Eastern Corn Belt (Ohio)			
Country Elevator	87.1	1.8	0.0	0.0	10.5	0.0
Terminal Elevator	16.7	83.3	0.0	0.0	0.0	0.0
River Elevator	0.0	0.0	100.0	0.0	0.0	0.0
Export Elevator	0.0	0.0	0.0	100.0	0.0	0.0
Feed Facility	20.0	0.0	0.0	0.0	80.0	0.0
Grain Processor	0.0	0.0	0.0	0.0	0.0	100.0
			Southern U.S. (Alabama)			
Country Elevator	88.0	0.0	8.0	1/	4.0	0.0
Terminal Elevator	50.0	50.0	0.0	1/	0.0	0.0
River Elevator	20.0	20.0	60.0	1/	0.0	0.0
Feed Facility	0.0	0.0	0.0	1/	100.0	0.0
Grain Processor	0.0	0.0	0.0	1/	40.00	60.0

1/ Since only one export plant was operating in Alabama, this plant type could not be included because the assumption of the discriminate analysis would be violated.

Corn Belt. In addition, the variables from the transportation sector were not as significant in the Eastern Corn Belt as they were in the Western Corn Belt. The bushels of permanent storage, the volume of feed processed, and grain storage for the firm and for others, and the number of farms were more important than the variables from the transportation sector for classifying firms in the Eastern Corn Belt.

Since the Eastern Corn Belt is a more diverse region which has smaller grain surpluses, smaller size of farms and less specialized grain facilities, these findings should not be surprising. In addition, delayed pricing options which originated in Ohio were an important variable for classifying firms.

The 18 variables accurately classified firms by type in the Eastern Corn Belt. The analysis required three discriminant functions to achieve 94 percent of the explanatory power and the cited measurements were nearly as significant as for the Western Corn Belt. The discriminant functions were able to accurately classify country and terminal elevators because the facilities in this region are less specialized in grain merchandising than in the Western Corn Belt.

The discriminant functions for the Alabama data identified 11 significant variables, the most important of these were receipts by transportation mode, volume of feed and grain processed and the percent of grain shipped to domestic points as a percent of total shipments. In the grain industry sector, storage, delayed pricing and drying functions were the important variables. In this deficit grain producing Southern region, the variables from the input sector were not significant for classifying firms. This finding is in sharp contrast to the results for both the Eastern and Western Corn Belt regions.

The discriminant functions were highly significant. The first function defined 61.8 percent of the explanatory power while two additional functions explained 20.1 percent and 16.5 percent, respectively. Country, terminal and

river elevators were not significantly differentiated since each type of firm received grain by water, re-shipped grain to end users and/or processed grain into feed. The variables used to differentiate all facilities except for feed processors were less useful than for the surplus grain producing regions.

Conclusions

Based on the different sets of variables among the three regions, the hypothesis that significant differences exist in the grain industry structure among regions is accepted. Furthermore, structural and functional data can be used to classify grain facilities. However, more detailed data on the composition of sales for grain, feed and non-farm sales and services are needed to better differentiate grain facilities in all regions. For the Western Corn Belt, differences in the country and terminal elevators may be so small that discriminant analysis techniques cannot accurately classify these facilities.

Differences in the significance of the variables to classify facilities by region from the input, output, transportation and grain merchandising sectors suggest that changes in policies or technologies which influence these variables will have different impacts upon the structure of the grain industry in each region. For example, the current rail line mergers will likely have more impact upon the structure of the grain industry in the corn belt regions which are shipping grain than upon the structure of the firms which are receiving grain in the south. The research described in this paper can be used to identify variables which impact the structure of the grain industry and can provide valuable insights for policymakers in the private and public sectors.

References

Caves, Richard E. "Organization, Scale, and Performance of the Grain Trade," Food Research Institute Studies, Vol. XVI, No. 3. Stanford University, pp. 107-123, 1977-78.

Clodius, Robert L and Willard F. Mueller. "Market Structure Analysis as an Orientation for Research in Agricultural Economics," Journal of Farm Economics. Vol XLIII, No. 3, August, 1961. pp. 515-553.

Jones, B.F., John W. Sharp and Dean Baldwin. "Structure of the Grain Market in Surplus Feed Grain Areas." Research Bulletin No. 927, Agricultural Experiment Station, Purdue University, West Lafayette, Indiana, October, 1975.

Larson, Donald W., Marcus E. Lower, E. Dean Baldwin and John W. Sharp. "U.S. Grain Marketing Structure in the 1970s." Paper presented at The National Conference on Grain Marketing Patterns. Memphis, Tennessee, March 12-13, 1981, 32 p.

Lower, Marcus E. "A Discriminant Analysis of the Grain Merchandising Industry's Structure for Three Regions (Western Corn Belt, Eastern Corn Belt, and South): 1977," unpublished M.S. thesis, Department of Agricultural Economics and Rural Sociology, The Ohio State University, March 1982, 200 pp.